VII

A TERTIARY MAMMALIAN FAUNA FROM THE MINT CANYON FORMATION OF SOUTHERN CALIFORNIA

By JOHN H. MAXSON

With eighteen text-figures

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CONTENTS

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INTRODUCTION

The Mint Canyon beds, typically exposed in Mint Canyon, seven miles northeast of Saugus, California, were described by Dr. W. S. W. Kew in Bulletin 753 (1924) of the United States Geological Survey. In 1919 during the course of geologic mapping of this region by Kew, fossil vertebrate remains were found at several localities. A provisional list of the vertebrates represented in the collection made at that time by Dr. Kew and by Dr. Chester Stock was recorded in Bulletin 753. However, no detailed study of the material was made. Further mammalian remains were secured from the Mint Canyon formation by Mr. J. W. Mitchell, Mr. Thomas Clements, Mr. H. J. Buddenhagen, by the Los Angeles Museum, and by the writer.

In view of the position of the Mint Canyon beds, immediately below a series of marine formations of the Pacific Coast Marine Province, the terrestrial fauna secured from these deposits is not only important in establishing the age of the Mint Canyon but also furnishes a basis for a comparison of the Tertiary record of this region with that of the Great Basin to the east. Opportunities to correlate the Tertiary record of the marginal marine province with the terrestrial record of the Great Basin on the basis of land vertebrates are infrequent and warrant in the present instance a careful survey of the Mint Canyon fauna.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to those who have assisted in the collection of the material. Prof. W. D. Matthew of the Department of Paleontology, University of California, has kindly loaned for study the original collection from the Mint Canyon beds. Especially does the writer wish to thank Prof. Chester Stock of the California Institute of Technology for criticism and assistance during the course of this study. The illustrations were prepared by Mr. John L. Ridgway.

LOCATION, RELATIONSHIPS AND PHYSICAL FEATURES OF MINT CANYON FORMATION

The fossiliferous Mint Canyon formation is exposed over an extensive area located in the northern part of the Fernando Quadrangle and in the southeastern part of the Tejon Quadrangle, Los Angeles County, California. These quadrangles cover portions of the hilly

country between Liebre Mountain on the northwest and the San Gabriel Mountains on the southeast. Mint Canyon is located on the north side of the Santa Clara Valley about halfway between the Los Angeles Basin and the Mohave Desert (see figure 1).

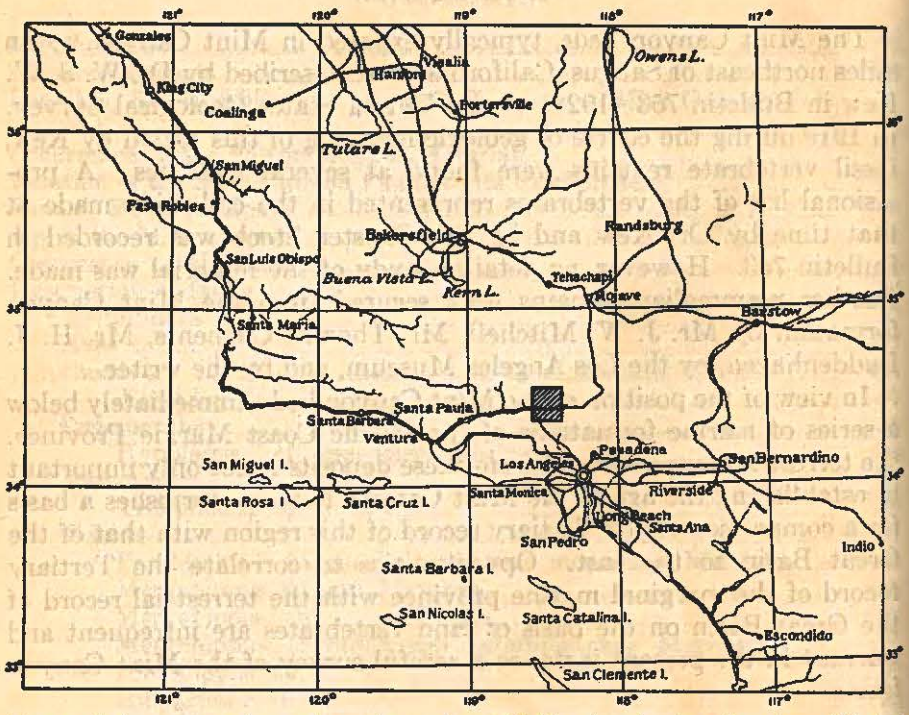

FIG. 1—Index map of portion of southern California showing location (shaded quadrangle) of Mint Canyon deposits.

The general geologic relationships of the Mint Canyon formation have been fully discussed by Dr. W. S. W. Kew. The observations recorded by Kew have been of considerable value to the writer during field work in this region.

The Mint Canyon deposits overlie unconformably the Sespe ? formation (upper Oligocene or lower Miocene). The latter beds tentatively assigned by Kew to the Sespe are not fossiliferous but have been correlated on the basis of lithology and stratigraphic position. Overlying the Mint Canyon formation with angular discordance is a marine formation referred by Kew[1] questionably to the Modelo. Recent studies of an invertebrate fauna from this formation have led Dr. W. P. Woodring[2] to state: "Rather poorly preserved specimens of *Astrodapsis* from this locality closely resemble *A.*

[1] W. S. W. Kew, U. S. Geol. Surv. Bull. 753, 52, 1924.

[2] W. P. Woodring, Abstract entitled "Age of the Modelo Formation of the Santa Monica Mountains, California," 28th annual meeting, Cordilleran Section, Geological Society of America, Stanford University, California, 1929.

tumidus and these beds are regarded as the approximate equivalent of the Cierbo formation." The determination would indicate that the marine beds are in part equivalent to the Modelo formation exposed at the type section near Modelo Canyon, as now restricted by Hudson and Craig.[1] This location is also north of the Santa Clara Valley but some distance to the west of Mint Canyon.

The association of primitive and advanced types within certain groups of mammals in the Mint Canyon fauna led the writer to search for a break in the sedimentary record of the formation, but none was observed. Beds comprising the formation are heterogenous and vary laterally. There is no well-marked break in type of sediments, although it was observed that beds of reddish tinge predominate in the lower part of the exposed section, intermingled brownish and grayish beds in the middle portion, and grayish colored deposits are particularly in evidence in the uppermost portion. Gray beds are, however, common throughout the formation, and the more highly colored deposits do not show sufficient regularity in their distribution to be useful in establishing zones.

The lower beds are largely coarse red sandstones with interbedded grayish and reddish silts. They are occasionally fossiliferous. In the middle part of the formation brown soily members and gray silty members, both fossiliferous, are interbedded with coarse, gray, cross-bedded conglomerates and fanglomerates. Several of the silty beds in this part of the formation contain many tests of the fresh-water gastropod, *Paludestrina imitator* Pilsbry.[2] These are apparently lacustrine deposits. Occasionally mammalian remains are found in these sediments.

As noted by Kew the Mint Canyon beds are involved in several rather sharp folds west of Bouquet Canyon, but elsewhere are gently folded with structural axes striking northeasterly. A thickness of 4,000 feet plus or minus is assigned by Kew to the entire formation. It appears to the writer that the thickness west of Mint Canyon itself does not greatly exceed 1,000 feet. Here the lower beds are faulted against a schistose basement complex to the north. Beds mapped by Kew as part of the Mint Canyon formation in a large area to the east of Mint Canyon differ lithologically from the deposits west of Mint Canyon, and yielded no fossils.

OCCURRENCE OF THE PALEONTOLOGICAL MATERIAL

The mode of accumulation of the Mint Canyon beds was apparently not favorable to burial of skeletal parts in association. Although effects of transportation were not noticed on specimens, they were probably scattered and exposed to weathering agencies before burial.

[1] F. S. Hudson and E. K. Craig, Bull. Am. Assoc. Pet. Geol., vol. 13, 509-518, 1929.
[2] W. S. W. Kew, *op cit.*, 54, 1924.

Broken teeth and bones are derived from soily accumulations. Lake and stream deposits occasionally contain fossils. Fossiliferous horizons are, however, infrequent. Good specimens are exceedingly rare.

RELATION OF THE MINT CANYON FAUNA TO ITS ENVIRONMENT

The Mint Canyon beds are exposed to the northwest of the San Gabriel Mountains. It appears not unlikely that the range contributed sediments to a broad valley on the northwest during Mint Canyon time. Adjacence to a prominent mountain mass of this type would apparently favor considerable local variety in environment.

Since the region in which the Mint Canyon deposits occur lies geographically contiguous to the Mohave Desert area and was presumably in direct communication with it during the period of accumulation of these sediments, one might expect to find similar environmental conditions prevailing at the Mint Canyon and Barstow localities. As a matter of fact, the similarities in faunal assemblages suggest that this was actually the case.

Seemingly the presence of relatively abundant remains of hypsodont horses, antelopes, camels and rabbits, indicates that the vegetation must have been at least as great as that supported by a semi-arid region. The climate was necessarily more humid than that characterizing the Mohave Desert at the present time.

Great numbers of fresh-water gastropods occurring locally in fine-grained sediments indicate the presence of fresh-water lakes. The occurrence in the Mint Canyon fauna of a turtle, possibly related to *Clemmys,* is supplementary evidence. Rabbits and large tortoises, related perhaps to *Testudo,* may have frequented the more arid districts. The grazing types of mammals with long crowned teeth occupied the grass-covered plains. *Parahippus,* the peccary, and possibly the oreodont, mastodon, and *Miolabis* may have found congenial wooded areas along the streams and beside the lakes.

FAUNAL RELATIONSHIPS

Correlation of the Mint Canyon assemblage with vertebrate faunas of the Pacific Coast Marine Province is rendered difficult by the dearth of comparable forms. It is immediately recognizable that *Merychippus californicus* characterizing the Merychippus zone at Coalinga is inferior in stage of development to the large protohippine types of *Merychippus* and *Hipparion*-like forms from the Mint Canyon. The latter assemblage is definitely later.

Some correspondence is found with the mammalian fauna from the Cuyama region, Ventura County, California, which is described by C. L. Gazin. This occurrence lies to the northwest of Mint

Canyon in the direction of Coalinga. Unfortunately paleontological correlation is possible only on the basis of *Merychippus sumani* which is common to both faunas. Although this similarity does not establish contemporaneity, it suggests agreement to within a comparatively small portion of a period.

Turning to the Great Basin Province we find faunas which are more completely known and which are more closely comparable to that of Mint Canyon. The closest correlative in distance and time, the Barstow, possesses an almost identical equine assemblage, common forms being *Parahippus, Merychippus intermontanus, Merychippus sumani* and *Protohippus.* However, the Mint Canyon fauna shows the introduction of *Hipparion ?* near *mohavense,* related to the Ricardo species, as well as other *Hipparion*-like types. The Ricardo fauna contains also *Pliohippus tantalus* and *Pliohippus fairbanksi* which are absent in both the Barstow and the Mint Canyon, while it lacks *Parahippus ? mourningi* found in the other two faunas. On the basis of the horses present, it would appear that the Mint Canyon is intermediate in age between the Barstow and Ricardo, perhaps bridging in a measure at least the hiatus between the two. The following table illustrates the relationships of these three faunas.

Comparative faunal lists of the Barstow, Mint Canyon and Ricardo

Barstow	Mint Canyon	Ricardo
Aelurodon near wheelerianus	Aelurodon, sp.	Aelurodon aphobus
Lepus	Hypolagus ? cf. apachensis	Lepus or Hypolagus
"Tetrabelodon"	Trilophodon sp.	Trilophodon sp.
Merycochœrus ? buwaldi	Oreodont cf. Merychyus	Merycochœrus (Metoreodon) californicus
Prosthennops ? sp.	Prosthennops ? sp.	
Merycodus necatus ?	Merycodus near necatus	Merycodus near necatus
Merycodus furcatus		Merycodus furcatus
Hypohippus near affinis		
Parahippus ? mourningi	Parahippus ? near mourningi	
Merychippus intermontanus	Merychippus intermontanus	
Merychippus sumani	Merychippus sumani Merychippus sp.	
Protohippus ? or Pliohippus ?	Protohippus sp. Hipparion ? near mohavense	Hipparion mohavense
	Hipparion ? sp.	
		Pliohippus tantalus
		Pliohippus fairbanksi

With the exception of *Alticamelus alexandræ*, the camels of the Barstow are at present too incompletely known to permit comparison with the Mint Canyon forms.

The Mascall fauna appears to be definitely older than the Mint Canyon. The advanced stage shown by *Parahippus ? mourningi* from the Barstow led Merriam to consider it as a primitive *Parahippus* rather than *Archeohippus*. Its advance over *Archeohippus ultimus* Cope from the Mascall is shown by greater size and by the loss of the external cingulum on the cheek-teeth. This difference is noted by Merriam.[1] Teeth of *Merychippus isonesus* from the Mascall are smaller and have a lighter coat of cement than those of *M. sumani*. In the camel group the Mascall and Mint Canyon formations possess comparable forms, *Miolabis transmontanus* and *Miolabis californicus*. The Mint Canyon species is somewhat smaller and more primitive in tooth structure. *Miolabis californicus* is apparently a survivor from an earlier stage in the Miocene.

Hipparion condoni Merriam from the Ellensburg formation of Washington is a primitive type and shows some points of similarity to one of the Mint Canyon forms, *Hipparion ?* sp. A. The appearance in both horizons of primitive Hipparions suggests a closer correspondence between the Mint Canyon and the Ellensburg than between the Mint Canyon and the Mascall.

The Mint Canyon does not admit of close correlation with deposits of the Great Plains Province because of geographic separation. The Santa Fé beds of New Mexico which are referred to the upper Miocene have some comparable forms. It is significant to note the presence of *Merychippus calamarius*, a species closely related to large protohippine horses of the Barstow. Two of these species, *Merychippus intermontanus* and *M. sumani*, are found also in the Mint Canyon. Proboscidea of the *Trilophodon* type occur in both deposits. Frick has established a close time relationship between the Santa Fé and the Barstow. On the basis of this correlation the Mint Canyon might be regarded as somewhat younger than the former horizon.

The Pawnee Creek beds of Colorado possess an earlier assemblage than the Mint Canyon, for like the Mascall the deposits have yielded *Merychippus isonesus*. Matthew[2] has correlated the Pawnee Creek beds with the lower Snake Creek beds of Nebraska because of a close correspondence of faunas. Merychippine forms of these formations are smaller and less advanced than the large protohippine types from the Barstow and Mint Canyon. The upper Snake Creek beds with *Pliohippus* and advanced *Hipparion* are younger than the Mint Canyon.

[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 477, 1919.
[2] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 72, 1924.

AGE OF THE MINT CANYON

The stratigraphic occurrence of a primitive *Merychippus, Parahippus ?* near *mourningi* and *Miolabis californicus* in the lower portion of the exposed Mint Canyon section might be considered as adequate paleontological evidence for assigning an older age to these beds, in which case an unconformity must be assumed. The presence of *Parahippus* in the Barstow detracts from its stratigraphic value in the Mint Canyon by extending the range of the genus into the upper Miocene, where it is found associated with more advanced forms. The occurrence of a primitive *Merychippus* does not indicate necessarily a hiatus between the beds containing this type and the deposits higher in the section. The camel on the other hand, because of its relationship with *Pseudolabis* and *Miolabis,* is suggestive of an older horizon. Aside from these forms with the limitations mentioned the fauna of the Mint Canyon beds has a unified character.

Time relationship of Mint Canyon fauna to Miocene vertebrate and invertebrate faunal horizons of western North America

Period	Pacific Coast Marine Province		Great Basin Province	Great Plains Province
	Marine	Terrestrial		
Upper Miocene	Santa Margarita		Ricardo	
	Cierbo	Mint Canyon	Barstow	Santa Fe
	Modelo			
	Briones		Cedar Mountain	
Middle Miocene	Temblor (Topanga)	Merychippus zone at Coalinga	Mascall and Virgin Valley	Lower Snake Creek

Faunal relationships suggest that the Mint Canyon formation is younger than the Mascall, Virgin Valley, and Cedar Mountain occurrences, while close to although somewhat younger than the Barstow. The Ricardo is slightly younger than the Mint Canyon. This evidence appears sufficient to assign an upper Miocene age to the formation. Further information bearing upon age is given by the stratigraphic position. If the overlying marine formation is of approximately Cierbo age as believed by Woodring, the Mint Canyon formation is precluded from occupying the uppermost part of the Miocene represented by the Santa Margarita and possibly by a portion of the Cierbo. The Mint Canyon formation is further depressed in the geologic column by the hiatus during which deformation and

erosion of the Mint Canyon beds occurred before submergence and deposition of the overlying marine series. Taking into consideration the facts available, it appears that the Mint Canyon beds were deposited during approximately the middle portion of the upper Miocene.

OCCURRENCE OF HIPPARION

A noteworthy feature of the equine group of the Mint Canyon fauna is the diversity of types represented. In this respect similarity to the Barstow fauna is suggested, for in the latter assemblage a wide variety of forms is also found. At both localities are recorded anchitheriine horses related to *Parahippus* or *Archeohippus*. Associated with this form are more progressive types of horses, identified as *Merychippus (Protohippus) intermontanus* and *Merychippus sumani*.

The advanced character of some of the protohippine horses of the Barstow, exhibiting apparently a relationship with the *Hipparion* group, was recognized by Merriam. It is of special interest to note that within the Barstow assemblage there prevailed considerable variation in structural characters at a time not long antecedent to the period of the Ricardo accumulation when a *Hipparion* type with comparatively primitive characters had become definitely established in the California region. In this connection Merriam [1] states: "While it is improbable that the known *Hipparion* forms of the Ricardo fauna are descended directly from any known *Hipparion*-like species of *Merychippus* of the Barstow fauna, the proximity of the two in morphologic characters, geographic situation, and in time, strongly suggest close relationship."

The collections from the Mint Canyon formation have yielded teeth more advanced in structural features than those referable to species of *Merychippus* and tending in some instances toward those characterizing the *Hipparion* group. These forms appear to be somewhat more progressive than the Barstow types, yet have apparently not quite reached the stage of development seen in the typical Hipparions of the Ricardo. An analysis of the characters presented by these forms has inclined the writer to refer them, until known by more complete material, at least tentatively to the genus *Hipparion*.

Should the disposition here made of the forms prove to be correct there may be added reason for assuming that the origin of the *Hipparion* group, as represented by species in the Ricardo, occurred in or near the Mohave area during the later Tertiary.

Moreover, the presence of *Hipparion* or *Hipparion*-like horses in the Mint Canyon, showing resemblances to the Ricardo species, is

[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 558, 1919.

significant as implying perhaps a greater antiquity to the Ricardo assemblage than has been hitherto assumed.[1]

DESCRIPTION OF FAUNA

Testudinata

Portions of a thick carapace and plastron as well as an associated limb bone indicate the presence in the Mint Canyon vertebrate fauna of a large land tortoise. The carapace has a maximum thickness of 4 cm. This form exceeds *Testudo mohavense* in size.

Fragments of the carapace of a small turtle are frequently encountered in the Mint Canyon formation. The specimens never exceed a thickness of approximately 8 mm. and in this character are to be distinguished from the large form mentioned above. The fragments may represent a freshwater turtle resembling *Clemmys*.

Aves

A proximal portion of a claw with a bony prominence on the inferior surface is the single record of a bird.

Carnivora

Ælurodon sp.

Remains of a single carnivore found in the Mint Canyon represent a canid type related presumably to *Ælurodon*. The material includes several teeth and tooth fragments, No. 125 C. I. T. Coll., belonging to one individual. The upper carnassial, still retained in a fragment of the maxilla, is shown in figure 2, *a* and *b*. A canine and second superior molar are shown in figures 2, *d* and *c*.

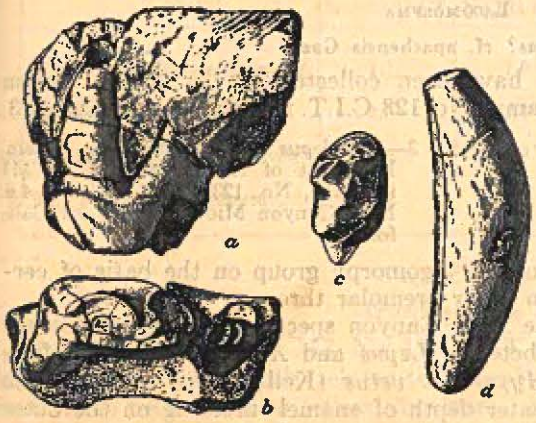

Fig. 2, *a* to *d*—*Ælurodon* sp., Teeth, No. 125 C.I.T. Coll.; *a*, P4, lateral view, *b*, P4, occlusal view, *c*, M2, occlusal view, *d*, C, lateral view; x 1.0. Mint Canyon Miocene, southern California.

[1] In recent years the presence of ***Hipparion mohavense*** in the Ricardo has suffered some loss of value as ***prima facie*** evidence in support of the view that this fauna is Pliocene in age. Thus Stock and Furlong suggest that the fauna may be, at least in part, transitional from Miocene to Pliocene. Recently Stock has recorded the species, ***Hipparion mohavense***, as coming presumably from the Puente formation of southern California. The recognition of ***Hipparion*** as an autocthonous type in America and the presence of the genus in faunas referred to the Pontian stage in Europe have led Matthew to regard the range of this form as extending backward into the upper

The crown of the canine is relatively slender. $P\frac{4}{4}$ is relatively short and broad compared with *Ælurodon aphobus* Merriam from the Ricardo. A groove situated on the anterior portion of the tooth suggests the presence of a parastyle. This cusp was apparently subdued. The crown gives little indication of the presence of a protocone, but the inner root is very strong. In this respect No. 125 is like *Ælurodon haydeni validus* Matthew and Cook.[1] The protocone ridge of $M\frac{2}{2}$ is almost obliterated by wear. The paracone was apparently the most important cusp.

The Mint Canyon form is much smaller than either *A. aphobus* or *A. haydeni*. The species from the Barstow regarded by Merriam as close to *A. wheelerianus* Cope from the Sante Fé is also larger in size. The protocone and parastyle are more prominently developed than in the Mint Canyon specimen.

Comparative measurements (in millimeters) of teeth

	Ælurodon sp. No. 125, C. I. T. Coll.	Ælurodon aphobus Merriam No. 21507 U. C. Coll.
C, height of crown	*a*10	
$P\frac{4}{4}$, anteroposterior diameter	21.6	32.3
$P\frac{4}{4}$, transverse diameter	10.4	15.
$M\frac{2}{2}$, anteroposterior diameter	9.3	
$M\frac{2}{2}$, transverse diameter	13.5	18.2

a, approximate

LAGOMORPHA

Hypolagus? cf. apachensis Gazin

A number of rabbit teeth have been collected in the Mint Canyon formation. A fragment of a ramus No. 123 C.I.T. is illustrated by figure 3.

FIG. 3—*Hypolagus?* cf. *apachensis* Gazin. Fragment of ramus with P3 to M1 inclusive, No. 123, C.I.T. Coll.; x 4.0. Mint Canyon Miocene, southern California.

Dice[2] distinguishes members of the lagomorph group on the basis of certain structural features seen in lower premolar three.

In size and cementation, the Mint Canyon specimens represent a stage of development intermediate between *Lepus* and *Archeolagus*. $P\frac{3}{3}$ differs from that of the genotype, *Hypolagus vetus* (Kellogg) from the Virgin Valley beds of Nevada, in greater depth of enamel infolding on the outer side of the tooth. On the inner surface is a groove not found in *H. vetus*. The Mint Canyon form differs widely from the genotype in smaller size.

Miocene. The occurrence of these types in the Mint Canyon underlying marine beds that are presumably upper Miocene in age may be regarded as confirmatory evidence in support of the view that the downward range of the *Hipparion* group is not limited to the Pliocene.

[1] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 100, 1924.

[2] L. R. Dice, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, 179-183, 1917.

In size $P\frac{3}{3}$ of the Mint Canyon form is close to that of *Hypolagus edensis* Frick from the Eden beds in the vicinity of Mount Eden, southern California, and also to that of *Hypolagus ? apachensis* Gazin [1] from the Cuyama region. The Mint Canyon species differs from *H. edensis* in the shape of $P\frac{3}{3}$ and in the position of the antero-external re-entrant angle. The enamel surface of the inner side is not grooved as in the Mint Canyon specimen or in the type of *H. ? apachensis*. In the latter the loops lie on a line nearly parallel to the longitudinal median, while in *H. edensis* the line to which the loops are tangent is directed inward at a large angle.

The lower molariform teeth have re-entrant angles which extend almost across the crowns. The loop curves posteriorly at its inner extremity. The inner side of each tooth is grooved in contrast to the rounded inner surface of the teeth in *H. edensis*.

The upper molariform teeth have a re-entrant angle with crenulated margins extending a little more than halfway across the crown.

Comparative measurements (in millimeters) of teeth

	Cuyama H. ? apachensis No. 38 C.I.T.	Mint Canyon H.? cf. apachensis No. 113 C.I.T.	H. vetus No.12565 U.C.	H. edensis No. 23376 U.C.
$P\frac{3}{3}$, anteroposterior diameter	2.3	2.4	2.9	2.4
$P\frac{3}{3}$, transverse diameter	2.0	2.2	2.8	2.1
$M\frac{1}{1}$, anteroposterior diameter	2.0	2.0	2.4	2.0
$M\frac{1}{1}$, transverse diameter	2.1	2.2	3.1	2.2
	No. 39 C.I.T.	No.131 C.I.T.		
$P\frac{4}{4}$, anteroposterior diameter	1.7	1.8		
$P\frac{4}{4}$, transverse diameter	2.6	2.7		
$M\frac{1}{1}$, anteroposterior diameter	1.8	1.8		
$M\frac{1}{1}$, transverse diameter	3.0	3.0		

PROBOSCIDEA

Trilophodon sp.

A nearly complete left $M\frac{3}{3}$, No. 120, C.I.T. Coll. (fig. 4 *a* and *b*), belongs to a mastodon presumably related to *Trilophodon*. Fragments of mastodon teeth have been found at several localities. In size the Mint Canyon form is much smaller than *Trilophodon pojoaquensis* Frick from the Santa Fé of New Mexico. No. 120 is considerably smaller than the *Trilophodon* sp. from the Ricardo and is somewhat larger than *Trilophodon productus* Cope from the Santa Fé. Four major crests and a rudimentary fifth crest are present on the tooth crown. The first two crests are worn and the third shows incipient wear.

[1] C. L. Gazin, this publication, No. VI, 67.

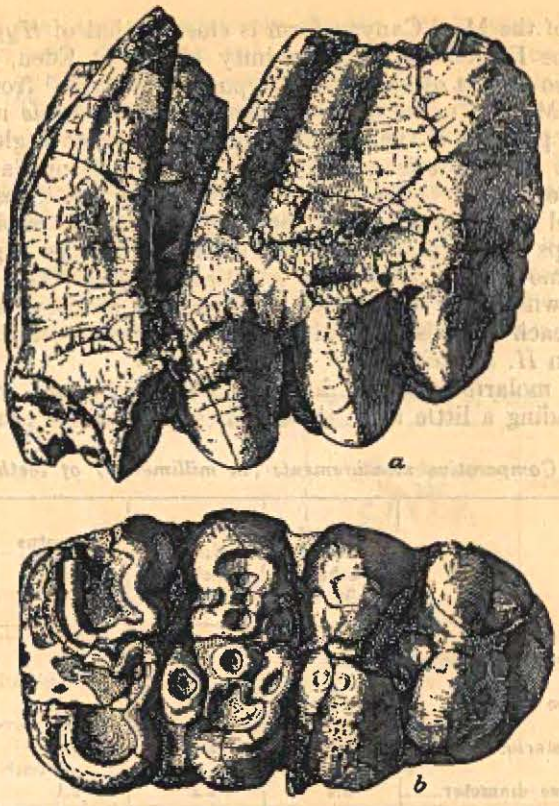

FIG. 4, *a* and *b*—*Trilophodon, sp.* M3, No. 120 C.I.T. Coll., *a*, lateral view, *b*, occlusal view; x 0.50. Mint Canyon Miocene, southern California.

A cingulum is missing. The first and second crests possess a pattern approximating in degree of complication the species *T. pojoaquensis*, while the third and fourth crests have each a single large tubercle on the outer side and two smaller cusps on the inner side. Fewer accessory tubercles are present on these crests than in *T. pojoaquensis*. Compared with *T. produc-*

Comparative measurements (in millimeters) of M3

	Trilophodon, sp. No. 120 C. I. T.	Trilophodon, sp. No. 1 L. A. Mus.	T. productus No. 4179 U. S. Nat. Mus.	T. pojoaquensis No. 21115 Am. Mus.
Antero-posterior diameter	156.5	172.7	143	197
Transverse diameter across first crest.	*a* 73.2	*a* 71		
Transverse diameter across third crest.	68.5	69.5		

a, approximate

tus, the pattern seems on the whole more complex. From the Ricardo *Trilophodon* the Mint Canyon specimen differs in greater complexity of the anterior two crests and the smaller number of tubercles present in the posterior portion of the tooth.

EQUIDÆ

Parahippus? (Archeohippus) near mourningi Merriam

Anchitheriine horses in the Mint Canyon assemblage are recorded by a fragment of a jaw belonging to an immature individual. This specimen, No. 23852 from Univ. Calif. Coll. Loc. 3554, possesses $Dm\overline{3}$ and $Dm\overline{4}$ and appeared as shown in figure 5, *a* and *b*. Subsequently the unerupted $P\overline{3}$ and $P\overline{4}$ were removed from the ramus. These teeth are illustrated in figure 5, *c* and *d*.

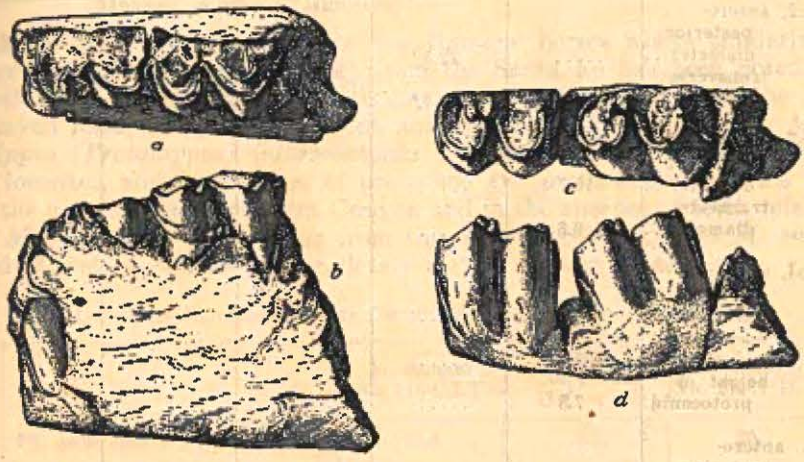

FIG. 5, *a* to *d*—*Parahippus? (Archeohippus)* near *mourningi* Merriam. Fragment of ramus with deciduous and permanent teeth, No. 23852 U.C. Coll., *a*, occlusal view of $Dm\overline{3}$ and $Dm\overline{4}$, *b*, lateral view of ramus and $Dm\overline{3}$ and $Dm\overline{4}$, *c* and *d*, $P\overline{3}$ and $P\overline{4}$, occlusal and lateral views; x 1.0. Mint Canyon Miocene, southern California.

An internal cingulum is absent on the milk teeth. The prominent cingulum on the anterior side of the crown becomes slight on the outer surface of the protoconid, but terminates in a pronounced cusp in the valley between the protoconid and hypoconid. There is no cingulum on the outer surface of the hypoconid, although a ledge is faintly developed on the posterior side of the crown. The genotype, *Parahippus cognatus* Leidy, is based on deciduous teeth, No. 567 U. S. Nat. Mus. $Dm\overline{2}$ in this form is larger than the deciduous molars of the Mint Canyon species. The metaconid-metastylid column and the entoconid-entostylid column are broader than in No. 23852. The brachydonty of the teeth is comparable.

The permanent teeth having suffered no attrition are rather long crowned. No cement is present and none is reported on the type of the species. The enamel surface is but very faintly rugose and in this respect differs from that in *Parahippus*. A cingulum is present only on the anterior side of the crown. The metaconid and metastylid columns are separated near the top of the crown. The form differs from *Hypohippus* in the absence of an ex-

ternal cingulum and in the separation of the metaconid and metastylid. The entostylid is developed much as in the type of the species.

No. 23852 is larger than any specimen referred to *Archeohippus*. *Parahippus ? mourningi* from the Barstow which has been assigned to *Archeohippus* by Osborn is somewhat smaller. *Parahippus pawniensis* Gidley from the Pawnee Creek beds is also smaller.

Comparative measurements (in millimeters) of lower teeth

	Parahippus near mourningi No. 23852 U. C.	Parahippus cognatus No. 567 U.S. Nat. Mus.	Parahippus mourningi No. 19764 U. C.	Archeohippus ultimus No. 1700 U. C.	Archeohippus penultimus No. 18950 Am. Mus. Nat. Hist.
Dm2, antero-posterior diameter ..	.....	22.5[1]			
transverse diameter ..	.....	12.5[1]			
Dm3, antero-posterior diameter ..	16.7	.....			
transverse diameter ..	*a* 9.8	.....			
Dm4, antero-posterior diameter ..	17.7	.....			
transverse diameter ..	*a*10	.....			
height of protoconid.	7.8	.....			
P3, antero-posterior diameter ...	16.8	.....	*a*15.8	12.0	10.1
transverse diameter ...	10.7	.....	10.5	9.8	9.0
height of protoconid..	15.7	.....	.....		
P4, antero-posterior diameter ...	17.2	.....	15.0	....	10.7
transverse diameter ...	11.2	.....	10.5	....	9.2
height of protoconid..	15.8	.....	.....		

[1] Measurements from figure 71, Osborn's *Revision of the Equidæ*, Mem. Am. Mus. Nat. Hist., N. S., vol. II, Part I, 95, 1918.

a approximate.

Merychippus sumani Merriam

An incomplete upper cheek-tooth, series No. 116 from C. I. T. Coll. Loc. 101 in the Mint Canyon formation, is referable to *Merychippus sumani*. As shown in figure 6, P2 and the inner portion of P4 are missing. The teeth are well worn.

As in the type of *M. sumani* from the Barstow the teeth are relatively small, curved and well cemented. The protocone is oval to subcircular in shape and is separate even in well-worn M1. The fossette borders are relatively complicated.

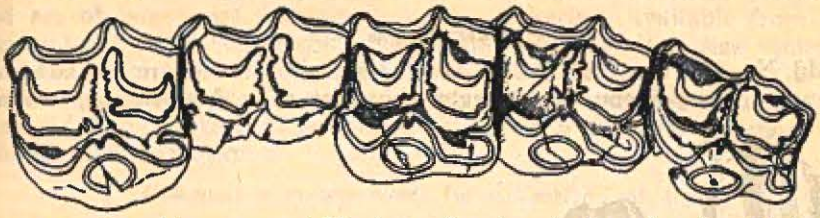

FIG. 6—*Merychippus sumani* Merriam. Superior cheek-tooth series, P2 to M2 inclusive, occlusal view, No. 116 C.I.T. Coll.; x 1.0. Mint Canyon Miocene, southern California.

M. sumani is the smallest of the Barstow horses whose similarity to *Merychippus calamarius* (Cope) from the Santa Fé has been noted. In teeth of *M. calamarius* the protocone is not symmetrical as in the Mint Canyon form, but gives rise to an anterior spur. The large form, *Merychippus (Protohippus) intermontanus* Merriam, differs in size, simplicity of fossettes, and early union of protocone and protoconule. On the basis of the material from the Mint Canyon and in the absence of teeth referable to *M. calamarius stylodontus* from this formation the species *M. sumani* and *M. intermontanus* appear clearly as two distinct types.

Comparative measurements (in millimeters) of upper cheek-teeth

	M. sumani No. 116 C.I.T.	M. sumani No. 21422, U. C. type	M. sumani No. 21401 U. C.
P2, anteroposterior diameter	21.4	.....	20
P2, transverse diameter	22.3	.....	21.9
P2, height of crown	21.6	.....	16
P4, anteroposterior diameter	21.0	22.0	20
P4, transverse diameter	.....	20.8	21.6
P4, height of crown	24.0		
M1, anteroposterior diameter	19.5	19	17.4
M1, transverse diameter	20.8	19.4	20.6
M1, height of crown	19.9		
M2, anteroposterior diameter	20.7	20.8	20
M2, transverse diameter	20.3	18.1	19.3
M2, height of crown	23.9	32.8	20
M3, anteroposterior diameter	21.0	19.7	
M3, transverse diameter	16.8	15.5	
M3, height of crown	23.0		

Merriam notes that in some characters of the cheek-teeth, *M. sumani* approaches *Hipparion*. According to Merriam, *M. sumani* is clearly distinguished from the latter genus by more strongly curved crowns, greater simplicity of fossettes, and a thinner coating of cement.

Merychippus sp.

M3, No. 18 from C. I. T. Coll. Loc. 97 and shown in figure 7, *a* to *c*, represents a *Merychippus* form slightly smaller than *Merychippus sumani*.

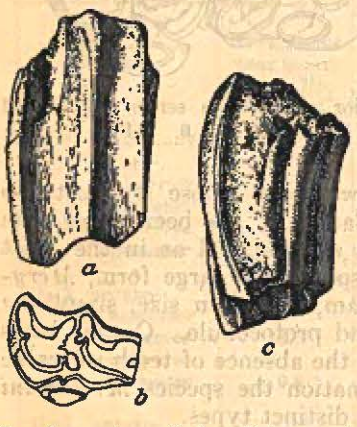

FIG. 7 *a* to *c*—*Merychippus* sp. M3, No. 18 C.I.T. Coll., *a*, outer view, *b*, occlusal view, *c*, posterior view; x 1.0. Mint Canyon Miocene, southern California.

In character of size, this specimen approaches *M. californicus* of the Merychippus zone of the North Coalinga region, California. The curvature of the crown, as seen in side view (fig. 7*c*), is comparable to that noted in last upper molar teeth belonging to a small species of *Merychippus* from the Barstow. The latter may represent *M. sumani*. In No. 18 C. I. T. the outer surface of the crown is devoid of cement, and the mesostyle, while somewhat worn, appears to be slender. The transverse diameter of the tooth diminishes very pronouncedly toward the grinding surface, perhaps no more so than in *Merychippus* teeth from the Barstow.

While the tooth is but slightly worn, the protocone is seen to occupy an almost median position on the inner side. This cusp is a flattened oval in cross-section and, judging from its form and position, is separated from the protoconule up to an advanced stage of wear. Plication of the fossettes resembles that in *M. californicus* and in small teeth of *Merychippus* from the Barstow. An unusual feature is presented in the postfossette, which remains open posteriorly. This opening prevails to the base of the crown. A similar character is exhibited by teeth of a more primitive type of *Merychippus* described by J. P. Buwalda [1] from the Phillips Ranch Miocene of the Tehachapi region, California.

Teeth of *M. californicus* exhibit considerable variation in size and enamel pattern. The Mint Canyon specimen is comparable to the smaller teeth representing *M. californicus*. The protocone in No. 18 is flatter and the anterior spur extending toward the protoconule, which is usually present in *M. californicus*, is absent in the former. A single tooth of *M. californicus*, No. 21280 U. C., figured by Merriam, [2] has a somewhat similar pattern. It is significant to note that while many teeth of *M. californicus* are avail-

[1] J. P. Buwalda, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, 78, 1916.
[2] J. C. Merriam, Trans. Am. Phil. Soc., N.S. vol. 22, Part II, 8, 1915.

able from the North Coalinga locality, not a single specimen has been observed in which the postfossette is open posteriorly after moderate wear.

Teeth of *M. sumani* from the Barstow, in comparison with No. 18 C. I. T. possess a protocone tending to become circular, a heavier coat of cement and are of larger size. However, in the collections available from this horizon teeth are present which approximate rather closely in size, cementation, and enamel pattern, No. 18 from the Mint Canyon. In view of the primitive character presented perhaps by the open postfossette in No. 18, it should be indicated that this tooth was found in the lower portion of the Mint Canyon formation.

Comparative measurements (in millimeters) of M3

	Merychippus sp. No. 18 C.I.T.	M. californicus No. 21246 U.C.	M. sumani No. 21422 U.C.
Anteroposterior diameter	18.1	17.7	19.7
Transverse diameter....	15.0	15.2	15.5
Height of crown.....	31.0	29.5	32.8

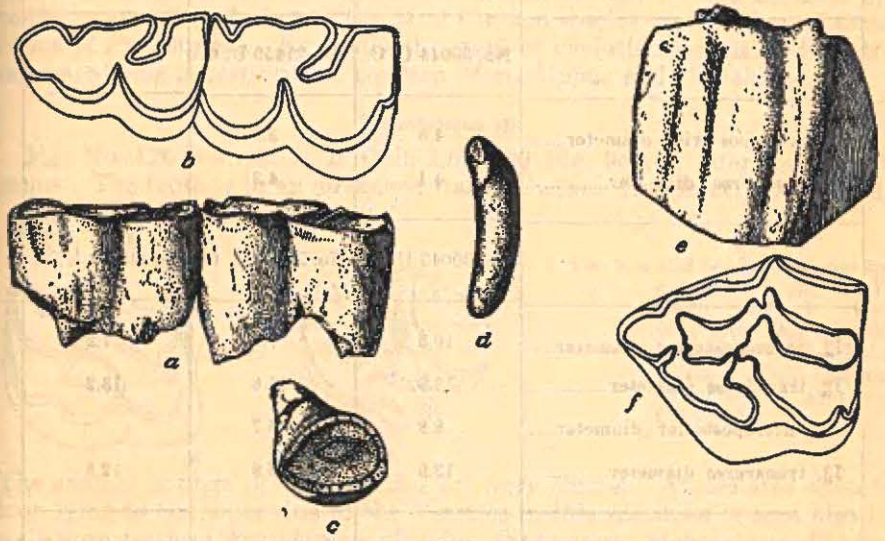

FIG. 8, *a* to *f*—*Merychippus (Protohippus) intermontanus* Merriam. *a* and *b*, P2 and P3, No. 30041 U.C. Coll., lateral and occlusal views, *c*, incisor, No. 30043 U.C. Coll., occlusal view, *d*, canine, No. 30044 U.C. Coll., lateral view, *e* and *f*, P2, No. 30042 U.C. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

Merychippus (Protohippus) intermontanus Merriam

A much worn P2, No. 30042 U. C. (fig. 8, *e* and *f*), and well-worn lower premolars two and three, No. 30041 U. C. (fig. 8, *a* and *b*), are assigned to this species. An incisor, No. 30043 U. C. (fig. 8*c*), and a canine, No. 30044 U. C. (fig. 8*d*), apparently belong to the same form. All specimens were found at Univ. Calif. Coll. Loc. 3555.

The fossettes in P2 are joined and communicate with the inner side of the tooth by a valley situated between the protocone and hypocone. The fossette borders are simple as in the type of the species. The enamel pattern noted in No. 30042 occurs in both merychippine and protohippine forms. *Merychippus sejunctus* (Cope) from the Pawnee Creek beds of northeastern Colorado and *Protohippus perditus* (Leidy) from the Niobrara River formation of Nebraska present a similar stage of development of tooth pattern. No. 30042 is much larger than the type of *M. sejunctus* and somewhat larger than that of *P. perditus*. *Merychippus (Protohippus) intermontanus* from the Barstow is similar in enamel pattern although somewhat smaller in size.

Comparative measurements of teeth (in millimeters)

	M. intermontanus No. 30042 U. C. Mint Canyon	M. intermontanus type No. 21400 U. C. Barstow	M. c. stylodontus No. 21404 U. C. Barstow
P2, anteroposterior diameter	32.1	27.8	28.9
P2, transverse diameter	24.2	18.5	24.2
P2, height of crown	29.0		
	No. 30044 U. C.	No. 21459 U. C.	
C, anteroposterior diameter	4.8	3.9	
C, transverse diameter	4.1	4.3	
	No. 30043 U. C.	No. 21459 U. C.	No. 21463 U. C.
I2, anteroposterior diameter	10.5	7.7	7.2
I2, transverse diameter	13.9	11.6	13.2
I3, anteroposterior diameter	8.8	a 5.7	
I3, transverse diameter	13.9	5.9	12.8
	No. 30041 U. C.	No. 21228 U. C.	No. 21392 U. C.
P2, anteroposterior diameter	21.3	21.2	21.8
P2, transverse diameter	15.0	.....	10.6
P3, anteroposterior diameter	21.0	20.4	20.4
P3, transverse diameter	17.0	14.2	12.0

a, approximate

The two lower premolars have a simple pattern (fig. 8, *a* and *b*), comparable to that found in *M. sejunctus* and *M. intermontanus* after con-

siderable wear. These teeth are much larger than the corresponding teeth of *M. sejunctus* and are heavily cemented. The metaconid-metastylid column is relatively short anteroposteriorly. The groove flattens out near the base of the crown. The entostylid is obliquely truncated anteriorly. These teeth resemble those of *Protohippus*.

As previously mentioned, the merychippine forms of the Barstow are closely interrelated. To quote from Merriam:[1] "The large *M. intermontanus* closely approaches the *M. calamarius stylodontus* form through the medium of specimens like No. 21409, in which the protocone unites with the protoconule in incipient wear and the fossettes have relatively simple borders. The crowns are, however, much larger in *M. intermontanus*." While a slight discrepancy in size remains, the similarity of crown pattern between the teeth from the Mint Canyon and those of the type from the Barstow seemingly warrants the recognition of the former as belonging to the *M. intermontanus* group.

The generic determination of these forms as *Merychippus* is doubtful. In this connection it is interesting to note that Merriam states: "In the series of *Merychippus* forms of the Barstow fauna as now known [1919], the range of characters very nearly includes the range from *Merychippus* to *Protohippus* and *Hipparion*. In the large *M. intermontanus* there is no clear separation from *Protohippus* on characters that have been used up to the present time." In size the Mint Canyon species exceeds that of some forms of *Protohippus*. Evidently the stage of evolution represented by *M. intermontanus* is transitional between *Merychippus* and *Protohippus*.

Protohippus sp.

M3, No. 126 from C. I. T. Coll. Loc. 100 (fig. 9*a*), is referable to this genus. The tooth is in an advanced stage of wear. It is heavily cemented.

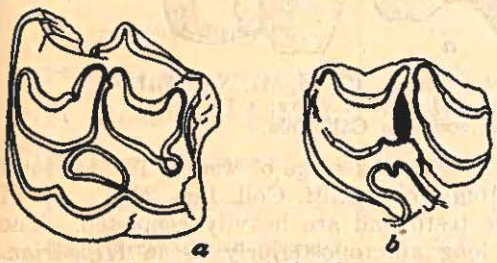

FIG. 9, *a* and *b*—*Protohippus* sp. *a*, M3, No. 126 C.I.T. Coll., occlusal view, *b*, upper cheek-tooth, No. 30045 U.C. Coll.; x 1.0. Mint Canyon Miocene, southern California.

The enamel borders of the fossettes are very simple. An isolated enamel loop lying to the inner side of the fossettes in this specimen is seen also in well-worn teeth of *Protohippus placidus*, *Protohippus niobrarensis*, *P. projectus* and *P. perditus secundus* as well as in some forms of *Pliohippus*. The crown of No. 126 is quite large and compares favorably in size with teeth of the larger members of the *Protohippus* group. No. 126 greatly exceeds teeth of *Merychippus* in size.

A portion of another upper cheek tooth, No. 30045 U. C., is also apparently referable to this genus. No. 30054 differs from teeth referred to *Merychippus* in the excessive simplicity of its regular crescentic fossettes. The protocone is united to the protoconule and the hypocone is apparently attached to the metaconule. A pli caballin is present. Figure 9*b* illustrates this tooth.

[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 484, 1919.

Comparative measurements (in millimeters) of M3

	Protohippus, sp. No. 126 C.I.T.	M. intermontanus No. 21400 U. C.	P. profectus No. 8349 Am. Mus.	Pliohippus spectans No. 22388 U.C.
Anteroposterior diameter	28.4	24.9	24	27.2
Transverse diameter	27.7	21.0	20	22
Height of crown..	19.7	....	36	

Hipparion ? sp. A.

Specimens representing this form are three lower cheek-teeth, No. 30047 from Univ. Calif. Coll. Loc. 3555 (fig. 10, *a* and *b*). The teeth show the

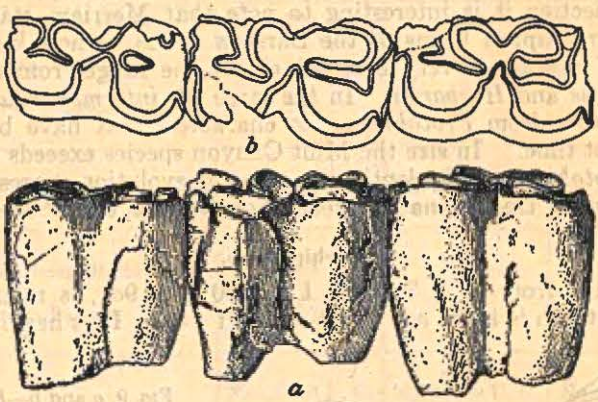

FIG. 10, *a* and *b*—*Hipparion ?* sp. A. P3, P4, M1, No. 30047 U.C. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

effects of weathering and are in an advanced stage of wear. To this form is also assigned M3, No. 30048 from Univ. Calif. Coll. Loc. 3564. All of the specimens are relatively large teeth and are heavily cemented. The metaconid-metastylid column is long anteroposteriorly as in *Hipparion*. The groove is especially well developed in P3, but in all of the teeth it continues to the base of the crown. This feature is not marked in *Merychippus* or *Protohippus*. The groove, however, is not so broad or deep as in most Hipparions. The teeth possess an antero-external enamel fold on the protoconid not found in *Pliohippus*. In size of cross-section they exceed the most advanced merychippine types.

The metaconid is considerably larger than the metastylid. The anteroposterior diameter of the column which they form is greater than that of *Hipparion condoni* Merriam from the Ellensburg formation of south-central Washington and is comparable to that in other species of *Hipparion*. Valleys adjacent to the metaconid-metastylid are compressed and serve to emphasize the large proportions of the column. The prominent antero-external ridge on the protoconid is likewise present in *H. condoni*. This ridge is small when found in *H. mohavense*.

Some differences are to be noted between the Mint Canyon form and several members of the genus *Hipparion*. Flattening of the exterior margin of the protoconid and hypoconid is not so marked as in species of *Hipparion*. The entoconid is large and projects anteriorly but there is no hypoconulid spur to be noticed on the inner margin. In general the valleys are compressed to a degree comparable to those in *Hipparion*.

From *H. mohavense* the Mint Canyon form differs in the shape of the entoconid, in the presence of a marked antero-external fold and in the preponderance in size of metaconid over metastylid.

These teeth represent a form of the size of *Hipparion* sp. B. from the Mint Canyon. The antero-external ridge is present on both. However, the metaconid-metastylid groove is not so broad or deep in species A. In *Hipparion ?* sp. B. the depth of the groove increases with wear. Likewise this form has a marked hypoconulid separated by a groove from the entoconid. In *Hipparion ?* sp. A. the isthmus is broad and is penetrated by an enamel tongue from the protoconid and hypoconid. In species B. the isthmus is narrow and the tongue does not seem to be appreciably deeper at the base of the crown than at the wearing surface. The differences in pattern do not seem to be entirely attributable to wear. The type of *Hipparion* represented by *Hipparion ?* sp. A. is somewhat closer to the protohippine stem than is either *Hipparion ?* sp. B. or *Hipparion mohavense*.

Comparative measurements (in millimeters) of lower cheek-teeth

	Hipparion ? sp. A. No. 30047 U. C.	H. condoni No. 672 Univ. Oregon	H. mohavense No. 19787 U. C.
P3, anteroposterior diameter	23.9	.....	23.5
P3, transverse diameter	15.3	.....	11.7
P3, height of crown	24.5		
P4, anteroposterior diameter	26.0	21.0	23.8
P4, transverse diameter	11.6	11.1	11.9
P4, height of crown	24.5	31.0	32.0
M1, anteroposterior diameter	22.4	17.6	
M1, transverse diameter	11.6	10.3	
M1, anteroposterior diameter of metaconid-metastylid column	14.2	11.2	

Hipparion ? sp. B.

The form represented by Nos. 114 and 115 C.I.T. Coll. Vert. Pale. is one of the largest of the Mint Canyon horses. A well-worn upper tooth (fig. 11, *c* and *d*), which may be M1, possesses a straight crown. The mesostyle is unusually heavy. The fossettes are relatively simple for *Hipparion*, especially the postfossette. The protocone is oval and larger than the hypocone. The former is still separate from the protoconule but the enamel borders

are tangent. The hypocone is strongly united to the metaconule. A pli caballin is present.

Simple fossette borders are usually diagnostic of *Protohippus*, while those of *Hipparion* are usually relatively complex. Crowns of *Hipparion* teeth are always nearly straight, whereas those of *Protohippus* are but occasionally straight. When considered in connection with the straightness of crown, the isolation of the protocone seems to indicate closer affinity with *Hipparion* than with *Protohippus*.

The two lower cheek teeth (fig. 11, *a* and *b*), considered as belonging to this type, were not found intimately associated with the upper molar. The specimens were found on opposite drainage slopes of the same exposure, although they may possibly have been derived from the same bed. The teeth are fairly complete, although they were collected in fragmentary condition. The enamel has largely flaked off.

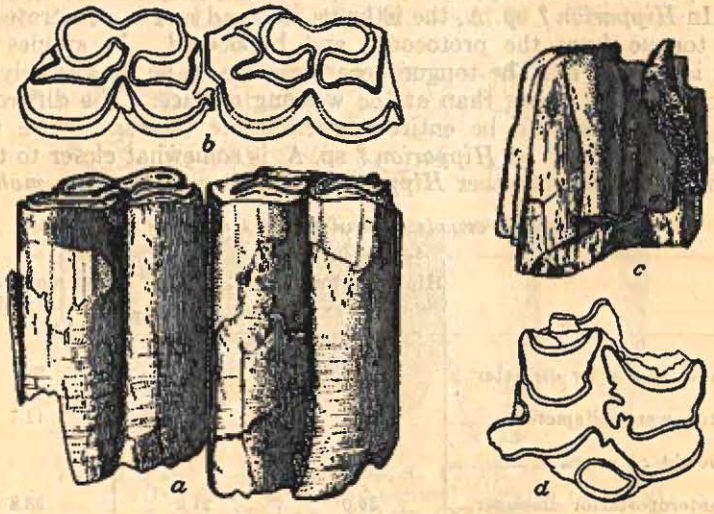

FIG. 11, *a* to *d*—*Hipparion?* sp. B. *a* and *b*, lower cheek-teeth, No. 115 C.I.T. Coll., lateral and occlusal views, *c* and *d*, upper cheek-teeth, No. 114 C.I.T. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

In these teeth as in those of *Hipparion?* sp. A., the outer margins of the protoconid and hypoconid tend to be more rounded than in most species of *Hipparion*. An antero-external ridge is present on the protoconid. The metaconid and metastylid columns are defintely separated to the base of the crown. The isthmus is narrow and the tongue of enamel from the protoconid and hypoconid does not penetrate it. The entoconid is somewhat rectilinear and a hypoconulid is present. The crowns are long and the pattern seems to warrant assigning the form tentatively to *Hipparion* rather than to any other genus.

The Mint Canyon type differs from *Merychippus sumani* and *Hipparion gratum* in much larger size. From *Hipparion mohavense* it differs in simpler fossette borders and rounder protocone. *H. platystyle* has a flatter protocone and the fossettes are narrower transversely. *Hipparion?* sp. B. may represent a type intermediate between *Protohippus* and *Hipparion* with perhaps a relationship tending more toward the latter genus than toward the former.

Comparative measurements (in millimeters) of teeth

	Hipparion ? sp. B. No. 114 C. I. T.	Hipparion ? sp. A. No. 30047 U. C.	Hipparion mohavense callodonte No. 21311 U. C.	Merychippus intermontanus No.21399U.C.
M1, anteroposterior diameter	26.2	.....	24.5	22.0
M1, transverse diameter	27.3	.....	22.6	26.0
M1, height of crown	27.0			
	No.115 C.I.T.			No. 21459 U. C.
P3, anteroposterior diameter	24.9	23.9	27.0	25.1
P3, transverse diameter	14.6	15.3	13.7	12.2
P3, height of crown	41.3	24.5		
P4, anteroposterior diameter	25.7	26.0	27.4	24.7
P4, transverse diameter	14.6	11.6	13.0	12.0
P4, height of crown	35.2	24.5	51.0	
P4, anteroposterior diameter metaconid-metastylid column	16.3	14.2		

Hipparion ? near mohavense Merriam

Two upper teeth, Dm4 and M1 (fig. 12*a*), No. 15 Los Angeles Museum Coll., from the Mint Canyon deposits presumably represent a species closely related to *Hipparion mohavense*. Occurring at the same locality (L. A. Mus. Coll. Loc. 1006) was a portion of a lower jaw containing P2, P3, and a portion of P4 (fig. 12, *b* and *c*), apparently referable to the same species. Specimen No. 124 from C. I. T. Coll. Loc. 100, including Dm3 and Dm4 (fig. 13*d*), and two upper molars (fig. 13*a* to *c*), and (fig. 13*e* to *h*), also belongs to this form. The upper teeth are slightly curved and are heavily cemented. The protocone is enlarged and separate, while the hypocone is reduced. Fossette borders are complicated. In the lower teeth the metaconid-metastylid column is separate to the base of the crown as is typical in *Hipparion*.

Among the infoldings of the enamel present on the crown are the pli crochet, pli caballin, pli prefossette, pli postfossette, and the pli hypostyle. One-fourth of the length of the crown from the bottom, the protocone is united to the protoconule. The juncture is effected at the anterior end of the protocone and the pli caballin has disappeared.

A number of enamel folds are present in the lower teeth. There is a tendency to form a small antero-external fold on the protoconid. As in *Hipparion mohavense collodonte* a fold is present on the anterior margin of the hypoconid with a corresponding fold projecting into the valley opposite it. The outer margins of the protoconid and hypoconid are more rounded than is usually the case in *Hipparion*.

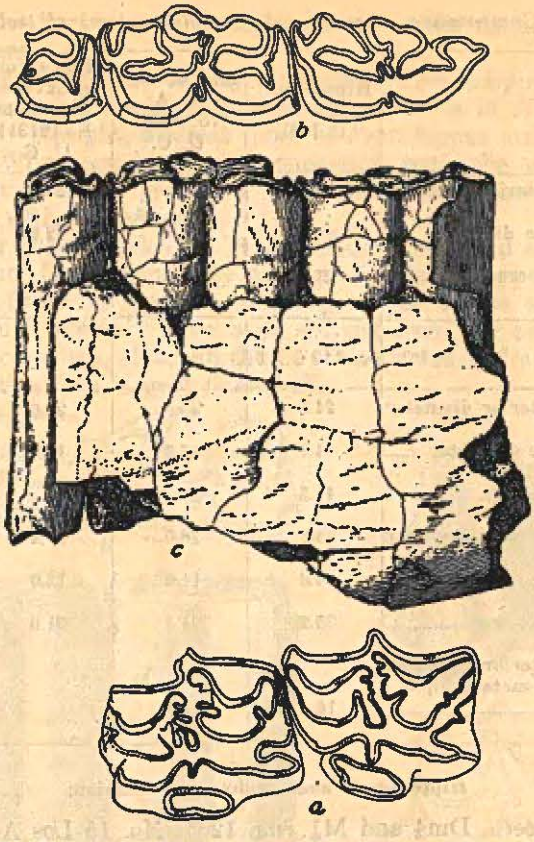

FIG. 12, *a* to *c*—*Hipparion ?* near *mohavense* Merriam. *a*, Dm4 and M1, No. 15 L.A. Mus. Coll., occlusal view, *b* and *c*, jaw fragment with P2, P3, and portion of P4, No. 15, L.A. Mus. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

Like the variety *Hipparion mohavense callodonte*, the Mint Canyon form exceeds *Hipparion mohavense* in size and in the anteroposterior length of the protocone. The crown surface of *H. mohavense callodonte* in contrast to that of the Mint Canyon species shows a large number of enamel plications which are distinctly angular. The differences in crown pattern may be due in part at least to wear. Teeth of the type specimen from the Ricardo are but slightly worn, whereas those of the Mint Canyon species are moderately worn. It has been recognized that the number and complexity of enamel folds may vary considerably within the range of the length of the crown. A section through the type specimen, No. 21311 U.C., made at a point approximately 4 mm. below the grinding surface exhibits a pattern more closely resembling that in teeth from the Mint Canyon.

The slightly greater curvature of crown of the upper cheek-teeth, greater simplicity of fossette borders, and an earlier union of protocone and protoconule in the Mint Canyon form, in contrast to the structural characters of the teeth in the Ricardo Hipparions, might be expected if the Mint

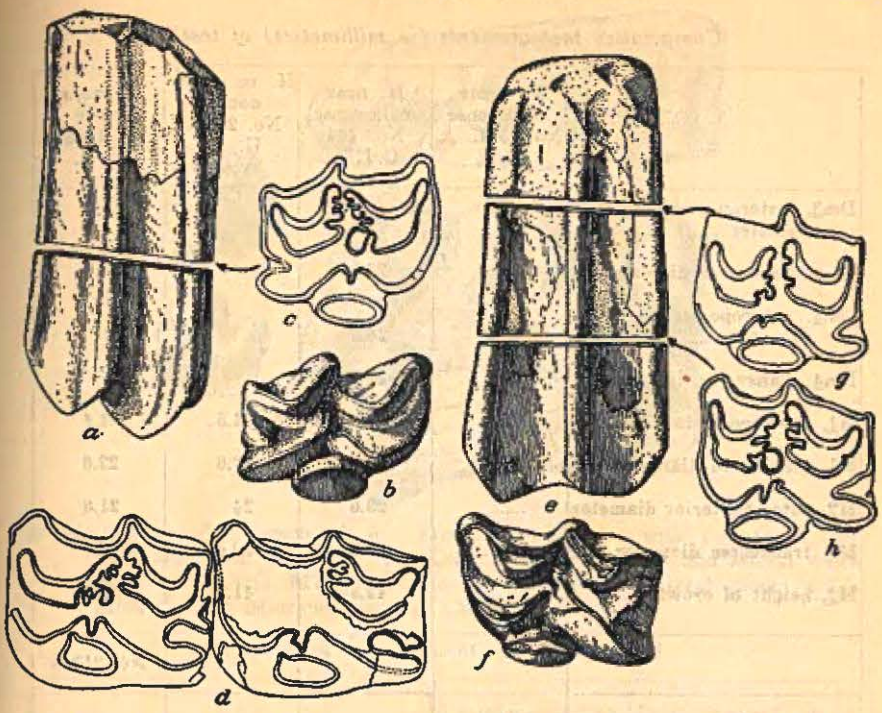

FIG. 13, *a* to *h*—*Hipparion ?* near *mohavense* Merriam. Permanent and deciduous upper cheek-teeth, No. 124 C.I.T. Coll. *a*, *b*, and *c*, M1 ?, lateral and occlusal views and section through crown, *d*, Dm3 and Dm4, occlusal views, *e* to *h*, M2, lateral and occlusal views and two sections through crown; x 1.0. Mint Canyon Miocene, southern California.

Canyon species were considered as a stage antedating the appearance of true *Hipparion*. Possibly the distinctions here noted are sufficiently diagnostic to warrant the recognition of a new specific type. If the Mint Canyon form falls within the limits of the genus *Hipparion*, the characters possessed by this type suggest one of the more primitive representatives of the group.

Merriam[1] has noted that *H. mohavense* seems more closely related to *H. richthofeni* of China than to previously described American forms. Concerning *H. mohavense callodonte* he remarks: "In many respects *Hipparion mohavense callodonte* of the Ricardo *Hipparion* group resembles a type from the Island of Samos, which has been referred to *H. gracile*. In this Samos form the protocone is much more compressed than in typical *H. gracile* and exceeds the degree of flattening in *H. m. callodonte*. The enamel folds are complicated much as in *H. gracile*, *H. richthofeni*, and *H. mohavense*."

Rhinocerotidæ

Rhinocerotid indet.

A fragment of a jaw of an immature animal, No. 20 L. A. Mus. Coll., belongs to a rhinocerotid type. Tooth fragments, No. 127 C. I. T., of an adult individual show a crown length of approximately 41 mm.

[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, No. 5, 557, 1919.

Comparative measurements (in millimeters) of teeth

	H. near mohavense No. 15 L. A. Mus.	H. near mohavense No. 124 C. I. T.	H. m. callodonte No. 21311 U. C. type	H. mohavense No. 19787 U. C.
Dm$\frac{3}{3}$, anteroposterior diameter	.....	26.9		
Dm$\frac{3}{3}$, transverse diameter	.....	23.1		
Dm$\frac{4}{4}$, anteroposterior diameter	27.3	28.3		
Dm$\frac{4}{4}$, transverse diameter	22.0	*a*22.6		
M$\frac{1}{1}$, anteroposterior diameter	27.8	26.0	24.5	21.4
M$\frac{1}{1}$, transverse diameter	22.8	22.8	22.6	22.0
M$\frac{2}{2}$, anteroposterior diameter	.....	23.6	24	21.6
M$\frac{2}{2}$, transverse diameter	.....	21.8	20.4	20.0
M$\frac{2}{2}$, height of crown	.....	42.3+	41.0	35.5
				No. 21348
P$\frac{2}{2}$, anteroposterior diameter	25.0	.....	28.4	23.8
P$\frac{2}{2}$, transverse diameter	12.9	.....	12.0	11.4
P$\frac{3}{3}$, anteroposterior diameter	25.3	.....	27.0	
P$\frac{3}{3}$, transverse diameter	14.5	.....	13.7	
P$\frac{4}{4}$, anteroposterior diameter	.....	.....	27.4	
P$\frac{4}{4}$, transverse diameter	*a*14.0	.....	13.0	
P$\frac{4}{4}$, height of crown	46.6	.....	51.0	44.0

a, approximate.

Tagassuidæ

Prosthennops ? sp.

A fragment of a mandibular ramus, No. 112 C. I. T. (fig. 14, *a* to *c*), was obtained at C. I. T. Coll. Loc. 98. This specimen includes a portion of Dm$\frac{4}{4}$ with P$\frac{4}{4}$ exposed below this tooth, M$\frac{1}{1}$ and M$\frac{2}{2}$, and indicates the presence of a dicotyline form. P$\frac{4}{4}$ was removed from the jaw and is shown in figure 14*c*. Fragments of a canine were associated with this material.

The canine has an inequilateral triangular aspect in cross-section, the outer slightly convex face being the broadest, the inner nearly flat face being next, and the posterior slightly concave surface being smallest in breadth.

Dm$\frac{4}{4}$ is very much worn and is being replaced by P$\frac{4}{4}$. The last premolar has two cusps on the anterior crest and a lower posterior crest. M$\frac{1}{1}$ exhibits a moderate state of wear, the cusps having been reduced. M$\frac{2}{2}$ is larger

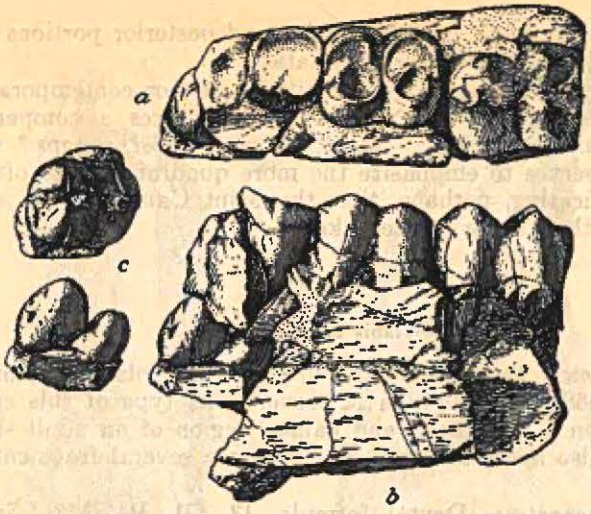

FIG. 14, *a* to *c*—*Prosthennops?* sp. Fragment of ramus with permanent and deciduous teeth, No. 112 C.I.T. Coll., *a* and *b*, occlusal and lateral views of jaw and $Dm\overline{4}$, $M\overline{1}$, and $M\overline{2}$, *c*, $P\overline{4}$, occlusal and lateral views; x 1.0. Mint Canyon Miocene, southern California.

Comparative measurements (in millimeters)

	Prosthennops ? sp. No. 112 C. I. T. Mint Canyon	Prosthennops ? sp. No. 23863 U. C. Rattlesnake
$Dm\overline{4}$, anteroposterior diameter	.....	17.9
$Dm\overline{4}$, transverse diameter	10.5	9.3
$P\overline{4}$, anteroposterior diameter	15.0	
$P\overline{4}$, transverse diameter	11.0	
$M\overline{1}$, anteroposterior diameter	16.0	16.6
$M\overline{1}$, transverse diameter	12.6	11
$M\overline{2}$, anteroposterior diameter	17.0	18.3
$M\overline{2}$, transverse diameter	13.8	12.8
Depth of lower jaw between $M\overline{1}$ and $M\overline{2}$	*a*30	34
Thickness of lower jaw below $M\overline{1}$	22	17.4
	No. 112 C.I.T.	No. 23866 U. C.
$C\overline{1}$, anteroposterior diameter	12.5	13.0
$C\overline{1}$, transverse diameter	8.3	8.0

a, approximate

than M1 and the cusps on the anterior and posterior portions of the tooth are separated by a transverse indentation.

Dearth of peccary material from either older or contemporaneous vertebrate horizons in western North America makes a comparison of the present specimen difficult. Comparison with *Prosthennops?* sp. from the Rattlesnake serves to emphasize the more quadrate aspect of the teeth in No. 112, indicating, perhaps, that the Mint Canyon form is not so far advanced as that of the Rattlesnake.

Camelidæ

Miolabis californicus n. sp.

Type specimen, No. 30046, University of California collection, from U. C. Coll. Loc. 3568, Mint Canyon Miocene. The type of this species is the greater portion of the facial and palatal region of an adult skull (fig. 15, *a* and *b*). Also associated with the type are several fragmentary skeletal elements.

Specific characters—Dental formula, I3, C1, P4, M3. Incisors relatively heavy. Slight reduction of premolars. P2 two-rooted. Molars subquadrate. Premaxilla not reduced. Muzzle short and elevated. Infraorbital foramen above posterior portion of P4 and anterior portion of M1. Shallow malar fossæ. Small size.

Miolabis californicus is among the smaller cameloid forms. It is smaller than *Miolabis transmontanus* (Cope) and is apparently comparable in size to *Paratylopus cameloides* (Wortman). The muzzle is short and relatively high, suggesting *Paratylopus sternbergi* (Cope). The apparent depression of the muzzle on the basifacial axis seen in figure 15*b* may be due to imperfect contact on a fracture. As in the genotype, *Miolabis transmontanus*, the muzzle is moderately compressed laterally.

The infraorbital foramen is situated above the anterior part of M1 and the posterior part of P4. A groove, the length of P4, projects anteriorly. In *Poëbrotherium wilsoni* Leidy, *Paratylopus sternbergi* (Cope), and *Protolabis montanus* Douglas this groove is situated farther forward.

The malar fossæ are broad and shallow in *M. californicus*. Illustrations of *Poëbrotherium wilsoni* and *Paratylopus sternbergi* given by Wortman do not show prominent fossæ. In this respect *M. californicus* appears similar to *P. sternbergi*. In the specimens of *P. cameloides* from the John Day described by Lull [1] there is a deep depression on either side of the maxillary.

The diastemata of *Poëbrotherium* are short and the genus is more primitive in this respect than *Miolabis*. *Paratylopus sternbergi* is comparable to No. 30046 in shape of skull and in the absence in deep malar fossæ. The John Day type is smaller than the Mint Canyon form. In *Protomeryx* as in *Paratylopus* the orbit is closed posteriorly. Unfortunately, this region is missing in the type of *M. californicus*.

Wortman notes that the P2 in *Miolabis transmontanus* is markedly reduced from that in *Paratylopus cameloides*. In *M. californicus* the premolar dentition is if anything heavier than in *P. cameloides*. M1 is subquadrate, while M2 and M3 are more elongate. The cheek-teeth are subhypsodont, being slightly higher crowned than those of *P. cameloides* and probably similar in this character to those of *M. transmontanus*. In *M.*

[1] R. S. Lull, Am. Jour. Sci., (5), vol. 1, pages 392-404, 1921.

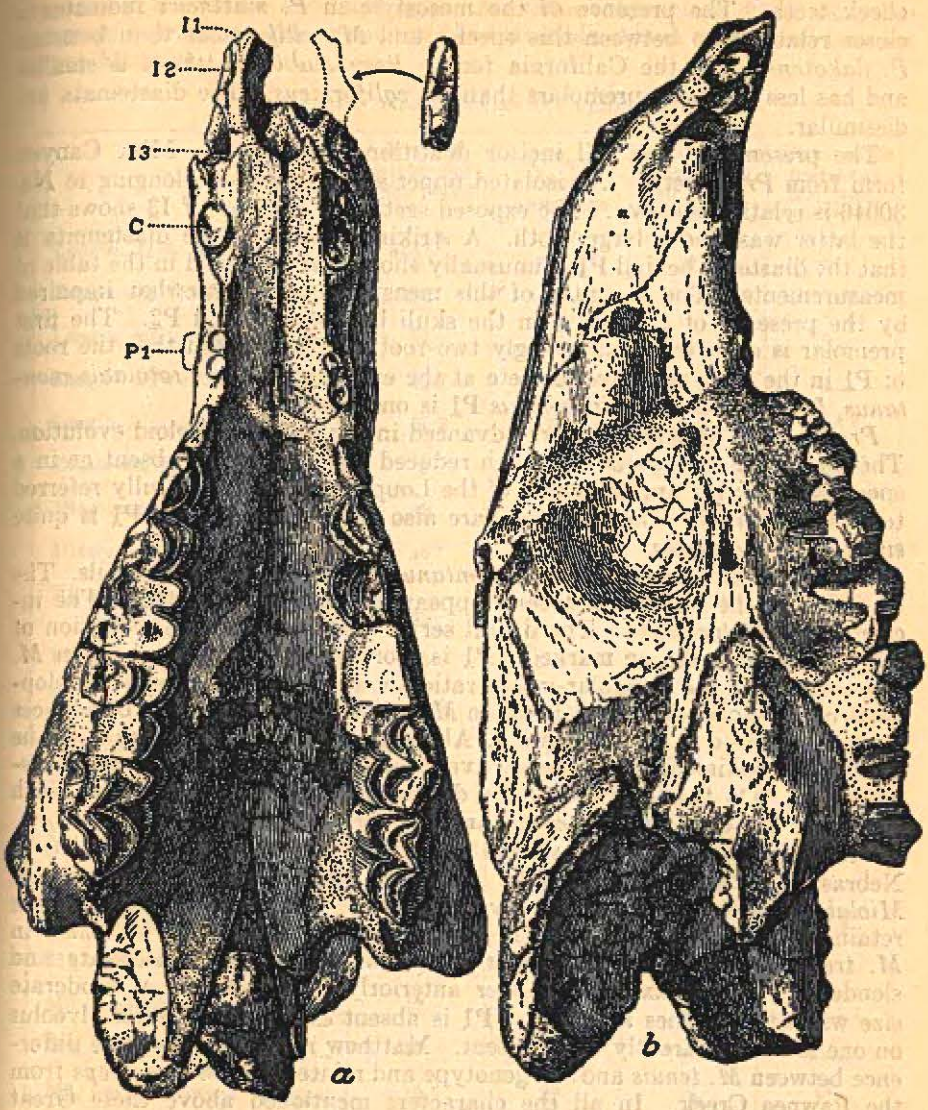

FIG. 15, *a* and *b*—*Miolabis californicus* n. sp. Skull, No. 30046 U.C. Coll., *a*, palatal view, *b*, lateral view; x. 0.75. Mint Canyon Miocene, southern California.

californicus the length from the anterior end of P2 to the posterior end of M3 is 82 mm. In *Paratylopus cameloides* (specimen No. 7915 Am. Mus. Nat. Hist.) this measurement is 83 mm.

Pseudolabis dakotensis Matthew[1] from the upper Oligocene (Protoceras beds of South Dakota) is comparable to *M. californicus* in size (P2-M3 in the former 83.7 mm., in the latter 82 mm.) although larger than *Pseudolabis (Paralabis) matthewi* Lull. In the genotype the mesostyle is lacking on

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 20, pages 211-215, 1904.

cheek teeth. The presence of the mesostyle in *P. matthewi* indicates a closer relationship between this species and *M. californicus* than between *P. dakotensis* and the California form. *Pseudolabis matthewi* is smaller and has less quadrate premolars than *M. californicus*. The diastemata are dissimilar.

The presence of the full incisor dentition separates the Mint Canyon form from *Procamelus*. An isolated upper second incisor belonging to No. 30046 is relatively heavy. The exposed section of the root of I3 shows that the latter was also a large tooth. A striking feature of the diastemata is that the diastema behind P1 is unusually short as is indicated in the table of measurements. The accuracy of this measurement is somewhat impaired by the presence of a fracture in the skull between P1 and P2. The first premolar is definitely and strongly two-rooted. Cope noted that the roots of P1 in the genotype were discrete at the extremities. In *Protolabis montanus, Procamelus* and *Alticamelus* P1 is one-rooted.

Protolabis is apparently more advanced in the line of cameloid evolution. The incisors in this genus are much reduced and I1 may be absent as in a specimen from the upper horizon of the Loup Fork beds doubtfully referred to *P. angustidens*. The premolars are also much reduced, and P1 is quite small in *P. montanus*.

No. 30046 differs from *M. transmontanus* in some important details. The dentition in the California species appears to be more primitive. The incisors are not spatulate. The dental series is shorter and the reduction of the premolars is not so marked. P1 is more strongly two-rooted. In *M. transmontanus* the premolar-molar ratio shows relatively greater development of the molars than is the case in *M. californicus*. Important differences are to be noticed in the diastemata. Although the skull itself is smaller, the diastemata behind I3 and C respectively are longer than those in *M. transmontanus*. On the other hand, the diastema between P1 and P2 is much shorter in the California species than in *M. transmontanus*.

Three species of camels from the lower part of the Sheep Creek beds of Nebraska, assigned to *Protolabis fissidens* Cope, *Miolabis longiceps* and *Miolabis tenuis*, are discussed by Matthew.[1] All three of these forms retain I1 and I2. Cheek teeth in *P. fissidens* are longer crowned than in *M. transmontanus*. In *M. tenuis* Matthew the muzzle is elongate and slender. The premaxilla is slender anteriorly. Incisors are of moderate size while the canines are small. P1 is absent except for a small alveolus on one side. Apparently P2 is absent. Matthew recognizes the wide difference between *M. tenuis* and the genotype and relates it to *M. longiceps* from the Pawnee Creek. In all the characters mentioned above these Great Plains forms differ from *M. californicus*.

The new species does not seem to be closely related to upper Miocene camels and affinity with preceding forms is not clear. *Paratylopus cameloides* does not appear adequate as the ancestral stock of *Miolabis californicus* in view of its deep facial fossæ, elongation of the muzzle, and more pronounced reduction of canines and incisors. In regard to the muzzle, the strongly two-rooted condition of P1 and size, *M. californicus* appears more primitive than the earlier *Miolabis transmontanus* and hence not derived from this form. *Pseudolabis (Paralabis) matthewi* in shortness of muzzle, spacing of anterior teeth and in general characters of dentition and skull

[1] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 190, 1924.

appears as a possible ancestral type. *Miolabis californicus* presumably belongs on a primitive side branch of the Camelidæ which persevered into the upper Miocene.

Comparative measurements (in millimeters)

	Miolabis californicus No. 30046 U. C.	Miolabis transmontanus	Paratylopus cameloides No. 10917 Yale P. Mus.	Pseudolabis matthewi No. 10167 Yale P. Mus.
Length, I_1 to M_3	*a*147?	257	.....	.....
Length, I_3 to M_3	131?	.....	.....	122
Length, P_2 to M_3	82	92	78.5	.....
Length, P_2 to P_4	31.7	35	.....	.....
Length, M_1 to M_3	50.3	57	.....	43.5
Diastema, I_3 to C	9	6	.....	5.5
Diastema, C to P_1	13	11	16	15.5
Diastema, P_1 to P_2	*a*6?	20	20	10
P_1, alveolus, anterosposterior diameter	10	.....	.....	.....
P_2, anteroposterior diameter	10	.....	.....	8
P_2, transverse diameter	4.6	.....	.....	.....
P_3, anteroposterior diameter	12.3	14	.....	9.5
P_3, transverse diameter	7	7.5	.....	.....
P_4, anteroposterior diameter	10.6	.....	11	9.5
P_4, transverse diameter	11.1	.....	10	.....
M_1, anteroposterior diameter	13.2	.....	13	12.5
M_1, transverse diameter	13.9	.....	.....	.....
M_2, anteroposterior diameter	17	18	17.3	.....
M_2, transverse diameter	15	18	16.5	.....
M_3, anteroposterior diameter	19.5	22	20	17
M_3, transverse diameter	16.8	19	17.4	.....

a, approximate.

Alticamelus ? sp.

The presence of large camels related perhaps to *Alticamelus* or *Megatylopus* is indicated by an incomplete proximal phalanx, No. 118 C.I.T. Coll. from locality 101. This specimen (fig. 16) is comparatively long and slender, corresponding in shape and size with No. 21563 U. C. Coll. from the Ricardo. No. 21564 U. C. referred by Merriam to *Pliauchenia ?* sp. is relatively shorter and stouter.

A jaw fragment containing one selene of a tooth appears to be that of a large camel. This fragment, No. 119 C. I. T., shows the depth of the jaw to be approximately 38 mm. and the height of the tooth along the inner side of the crescent to be approximately 19.5 mm.

FIG. 16—*Alticamelus?* sp. Proximal phalanx, No. 118 C.I.T. Coll., anterior view; x 0.50. Mint Canyon Miocene, southern California.

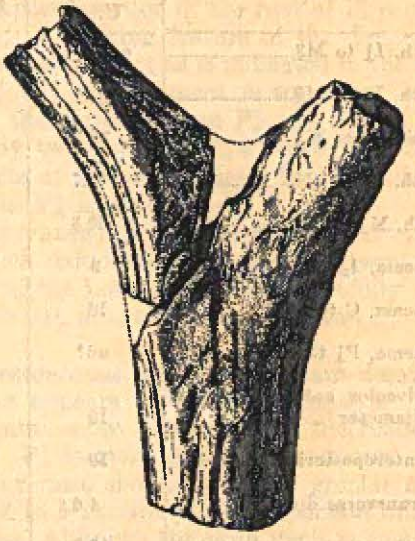

FIG. 17—*Merycodus* near *necatus* Leidy. Fragment of antler, No. 130 C.I.T. Coll.; x 1.0. Mint Canyon Miocene, southern California.

Antilocapridæ

Merycodus near necatus Leidy

Two antler fragments of *Merycodus* showing the region of bifurcation are included in the collection. In No. 130 C. I. T. from locality 103 (fig. 17), the basal portions of the ascending tines are present. Insofar as comparison can be made, this specimen resembles *Merycodus* antlers from the Barstow. In the flattening of the beam, angle of bifurcation of the tines, and in size No. 130 resembles closely material (No. 1399 U. C. Coll.) from the Mohave Miocene referred to *M. necatus*. Toe bones, No. 121 C. I. T., and a fragment of an upper maxillary with a cheek-tooth, No. 122 C.I.T., are referred to *Merycodus*.

Antilocaprid indet.

An enamel fragment of a cheek-tooth indicates the presence of a large antelopine form. The fragment pertains to a selenodont tooth of considerable hypsodonty. Its height is 35 mm. The subdued character of the styles is indicative of affinity with the Antilocapridæ. The two Barstow forms referred to *Merycodus necatus* and *Merycodus furcatus* are much smaller. *? Merycodus altidens* Matthew from the Upper Snake Creek beds is a form of comparable size, as are also members of the genera *Ilingoceras* and *Sphenophalos*.

Oreodontidæ

Oreodont cf. Merychyus

A posterior portion of a left ramus of the mandible from U. C. Coll. Loc. 3555 ? is referred to a small oreodont. The specimen is illustrated in figure 18. The larger part of a worn $M\bar{1}$ and a practically unworn $M\bar{3}$ are

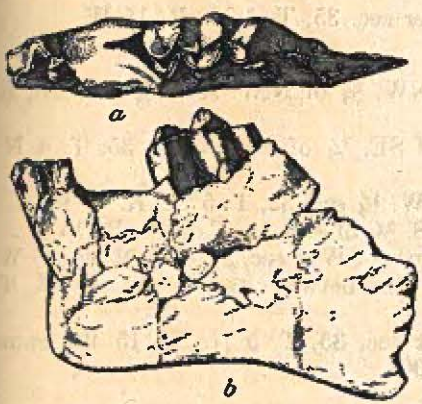

FIG. 18, *a* and *b*—Oreodont, cf. *Merychyus*. Fragment of ramus, U.C. Coll., *a* occlusal view, *b*, lateral view; x 1.0. Mint Canyon Miocene, southern California.

present in the jaw fragment. The molars are selenodont and hypsodont. The selenes of the teeth tend to terminate more acutely exteriorly and the valley between them is deeper than in typical cervid or antilocaprid teeth. No prominent style is present on the median inner surface of the tooth as in cervids. The posterior lobe of $M\bar{3}$ does not appear to be as flat as in $M\bar{3}$ of oreodonts. The characters noted are on the whole perhaps more strongly suggestive of an oreodont than of other Miocene artiodactyla.

The genus *Merycodus*, somewhat comparable in size, has a thinner and lighter ramus. In the Mint Canyon specimen the ramus increases rapidly in depth beneath $M\bar{3}$. This tendency toward an expanded circular outline of the angle is especially noticeable among the oreodonts. Figures of *Merychyus delicatus* Loomis and *Merychyus paniensis* Loomis illustrate this feature. The Mint Canyon type is somewhat smaller than *M. delicatus*. Teeth from the Virgin Valley beds tentatively referred by Merriam to *Merychyus* are somewhat heavier than those of the Mint Canyon form. The approximate measurements (in millimeters) of the oreodont specimen from the Mint Canyon are as follows: length from anterior end of $M\bar{1}$ to posterior end of $M\bar{3}$, 35; anteroposterior diameter of $M\bar{1}$, 9; anterposterior diameter of $M\bar{3}$, 17; depth of jaw below $M\bar{2}$, 22.

LIST OF MINT CANYON FOSSIL LOCALITIES

All Townships and Ranges referred to San Bernardino Base and Meridian.

All localities in Fernando Quadrangle except No. 97 C.I.T. which is in the Tejon Quadrangle.

University of California:

Locality 3554: SE. ¼ of SW. ¼ sec. 30, T. 5 N., R. 14 W.
Locality 3555: Center of sec. 35, T. 5 N., R. 15 W.
Locality 3564: West line of sec. 35, T. 5 N., R. 15 W.
Locality 3565: S.W. corner of NE. ¼ sec. 36, T. 5 N., R. 16 W.
Locality 3566: N. ½ of NE. ¼ sec. 36, T. 5 N., R. 16 W.
Locality No. not assigned: Center of SW. ¼ sec. 26, T. 5 N., R. 15 W.
Locality 3568: Center of SE. ¼ sec. 30, T. 5 N., R. 14 W.
Locality 3571: N.W. ¼ of SW. ¼ sec. 35, T. 5 N., R. 15 W.

Los Angeles Museum:

Locality 1006: SW. corner sec. 35, T. 5 N., R. 15 W.

California Institute of Technology:

Locality 97: W. line of NW. ¼ of N.W. sec. 14, T. 5 N., R. 16 W.
Locality 98: N. center of SE. ¼ of SE. ¼ sec. 35, T. 4 N., R. 15 W.
Locality 99: Center of SW. ¼ sec. 32, T. 5 N., R. 15 W.
Locality 100: Center of S. ½ of sec. 34, T. 5 N., R. 15 W.
Locality 101: NW. portion of SW¼ sec. 31, T. 5 N., R. 15 W.
Locality 102: N. 1/3 of line between sec. 3 and sec. 4, T. 4 N., R. 15 W.
Locality 103: SW. corner sec. 35, T. 5 N., R. 15 W., same as L. A. Mus. No. 1006.